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# Investigating the Impact of Digital Wiki Boards and KWL Strategy on Creative and Analytical Thinking in Elementary Education

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***Abstract***

Abstract (English)

the development of creative and analytical thinking has become a key priority in elementary education in response to increasing 21st-century learning demands. This study aimed to examine the impact of integrating Digital Wiki Boards and the KWL (Know–Want to know–Learned) strategy on students' higher-order thinking skills in an elementary school context in Indonesia. A quasi-experimental design with a non-equivalent control group was employed, involving 70 students divided into experimental and control groups. Data were collected using validated instruments measuring creative and analytical thinking through pre-test and post-test procedures. Data analysis included independent samples t-tests, effect size estimation, and normalized gain analysis. The results revealed a statistically significant difference between groups ($t(68) = 6.95$, $p < .001$), with the experimental group outperforming the control group. The effect size was very large (Cohen's $d = 1.66$), indicating substantial practical impact. These findings suggest that the integration of collaborative digital tools with structured metacognitive strategies effectively enhances higher-order thinking skills. This study highlights the importance of aligning technology use with pedagogical scaffolding to support cognitive development in elementary education

Abstrak (Indonesia )

Pengembangan pemikiran kreatif dan analitis telah menjadi prioritas utama dalam pendidikan dasar sebagai respons terhadap meningkatnya tuntutan pembelajaran abad ke-21. Studi ini bertujuan untuk meneliti dampak integrasi Papan Wiki Digital dan strategi KWL (Know–Want to know–Learned) terhadap keterampilan berpikir tingkat tinggi siswa dalam konteks sekolah dasar di Indonesia. Desain kuasi-eksperimental dengan kelompok kontrol non-ekuivalen digunakan, melibatkan 70 siswa yang dibagi menjadi kelompok eksperimen dan kontrol. Data dikumpulkan menggunakan instrumen yang telah

divalidasi untuk mengukur pemikiran kreatif dan analitis melalui prosedur pre-test dan post-test. Analisis data meliputi uji t sampel independen, estimasi ukuran efek, dan analisis gain yang dinormalisasi. Hasil penelitian menunjukkan perbedaan yang signifikan secara statistik antar kelompok (t(68) = 6,95, p < 0,001), dengan kelompok eksperimen menunjukkan kinerja yang lebih baik daripada kelompok kontrol. Ukuran efeknya sangat besar (Cohen's d = 1,66), menunjukkan dampak praktis yang substansial. Temuan ini menunjukkan bahwa integrasi alat digital kolaboratif dengan strategi metakognitif terstruktur secara efektif meningkatkan keterampilan berpikir tingkat tinggi. Studi ini menyoroti pentingnya menyelaraskan penggunaan teknologi dengan dukungan pedagogis untuk mendukung perkembangan kognitif di pendidikan dasar.

Kata kunci: analytical thinking; creative thinking; digital wiki boards; elementary education; KWL strategy



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## 1. INTRODUCTION

In the contemporary landscape of elementary education, fostering higher-order thinking skills—particularly creative and analytical thinking—has become a central educational objective. As the demands of the 21st century continue to evolve, students are expected not only to absorb information but also to evaluate, synthesize, and generate new ideas from complex data(Ekizer & Yıldırım, 2023). This paradigm shift has driven the adoption of instructional approaches that move beyond rote learning, emphasizing learner-centered pedagogies that promote active cognitive engagement and metacognitive reflection (Merkebu et al., 2023). Within this context, the integration of digital technologies and structured learning strategies has emerged as a promising pathway for enhancing cognitive competencies at the primary education level.

One digital tool gaining increasing attention is the digital wiki board a collaborative web-based platform that enables learners to co-construct knowledge through both asynchronous and synchronous interactions. Prior research indicates that digital wikis provide open-ended environments where students can negotiate meaning, engage in peer feedback, and collaboratively edit content, thereby supporting the development of creativity and analytical rigor (Sigalov & Cohen, 2025). The collaborative affordances of wikis align closely with socio-constructivist principles, which conceptualize knowledge construction as a socially mediated process grounded in interaction and shared experience (Vygotsky, 1978). Such participatory learning environments are particularly relevant in elementary education, where guided exploration and scaffolding are essential for sustaining motivation and optimizing learning outcomes (Salsabila & Muqowim, 2024).

However, the pedagogical potential of digital collaboration is not automatically realized. Without structured cognitive guidance, digital learning environments may result in fragmented participation or surface-level engagement. Consequently, instructional scaffolds that explicitly support learners' cognitive and metacognitive processes are increasingly viewed as essential complements to educational technology. Among these scaffolds, the KWL (Know–Want to Know–Learned) strategy has been widely recognized for its effectiveness in structuring inquiry-based learning and fostering reflective thinking. Initially developed to support reading comprehension, KWL has evolved into a versatile metacognitive framework applicable across subject areas and educational levels(Sercenia & Prudente, 2023). When

embedded within digital learning environments, KWL supports learners in planning learning goals, monitoring inquiry processes, and evaluating newly acquired knowledge—processes that are fundamental to both creative ideation and analytical evaluation (Hu et al., 2022; Thaw et al., 2025).

Despite growing interest in both digital wikis and the KWL strategy, empirical research has largely examined these approaches in isolation. Existing studies predominantly focus on secondary or higher education contexts, with limited attention to elementary learners and their distinctive cognitive characteristics (Nasution et al., 2023; Neslihan & Muamber, 2022; Sari et al., 2023). Moreover, the integrative implementation of collaborative digital platforms and structured metacognitive strategies remains underexplored, particularly within non-Western educational settings. This gap is significant, as elementary students require instructional designs that balance technological openness with pedagogical structure to effectively support higher-order thinking development.

Empirical evidence suggests that the KWL strategy alone can enhance comprehension, reflection, and motivation by guiding learners through phases of knowledge activation, inquiry, and consolidation (Liu & Pásztor, 2022; Sercenia & Prudente, 2023). In elementary classrooms, visual and structured KWL representations have been shown to strengthen students' understanding and engagement in learning activities (Nasution et al., 2023; Nurlisa et al., 2023). Complementing these findings, a quasi-experimental study conducted in Indonesia reported that the integration of collaborative wikis and KWL strategies significantly improved students' cognitive achievement and learning motivation compared to conventional instruction ($F(1,117) = 28.59$, $p < 0.001$) (Andrayani et al., 2025). While these results provide preliminary support for the combined use of both approaches, further empirical investigation is required to examine their impact specifically on creative and analytical thinking skills within elementary education.

Addressing this research gap, the present study investigates the combined effect of digital wiki boards and the KWL strategy on the development of creative and analytical thinking skills among elementary school students using a quasi-experimental design. This study explores how the integration of collaborative digital tools and structured metacognitive scaffolding supports higher-order thinking processes in elementary learning contexts, while also examining the role of student participation and metacognitive engagement in shaping cognitive outcomes.

The novelty of this study is articulated in three key dimensions. First, it empirically examines the *synergistic integration* of digital wiki boards and the KWL strategy, moving beyond prior studies that have treated digital collaboration and metacognitive scaffolding as independent interventions. Second, it extends the existing literature by focusing on elementary school learners within a non-Western educational context, thereby addressing a critical gap in technology-enhanced learning research. Third, it emphasizes the *practical magnitude* of instructional effects by employing effect size analysis alongside statistical significance testing, providing robust evidence of the educational impact of the intervention.

This study explicitly contributes to the field by advancing empirical understanding of how collaborative digital environments and metacognitive frameworks can be harmonized to foster creative and analytical thinking from an early age. By situating its findings within socio-constructivist and metacognitive perspectives, the study offers both theoretical insights and practical implications for the design of evidence-based, technology-enhanced instructional models in elementary education.

## 2. METHODS

### Research Design

This study employed a quasi-experimental design with a non-equivalent control group to examine the effect of integrating Digital Wiki Boards and the KWL (Know–Want to know–Learned) strategy on students' creative and analytical thinking skills. This design was selected to allow systematic comparison between experimental and control groups in an authentic classroom context, where random assignment was not feasible, while preserving ecological validity.

### Participants

The study was conducted in a public elementary school within a formal classroom setting. A total of 70 students were selected using purposive sampling and assigned to two intact classes: an experimental group ($n = 35$) and a control group ($n = 35$). The experimental group received instruction through the integration of Digital Wiki Boards and the KWL strategy, whereas the control group followed

conventional teacher-centered instruction. The intervention was implemented over eight consecutive weeks and aligned with the national curriculum to ensure contextual relevance.

### Instruments

Data were collected using two validated instruments. Creative thinking was assessed using an adapted version of the Torrance Tests of Creative Thinking (TTCT), measuring fluency, flexibility, originality, and elaboration. Analytical thinking was measured using a researcher-developed test based on Bloom's taxonomy, focusing on reasoning, comparison, and inferential skills. Both instruments were administered as pre-tests and post-tests. To ensure scoring reliability, open-ended responses were independently evaluated by two trained raters, achieving an inter-rater reliability coefficient (Cohen's kappa) above 0.85, indicating strong agreement.

### Data Analysis

Data analysis was conducted using Independent Samples t-tests to examine baseline equivalence and post-intervention differences between the experimental and control groups. This approach enabled an unbiased estimation of the treatment effect. Prior to hypothesis testing, assumptions of normality and homogeneity of variance were verified. All statistical analyses were performed using appropriate statistical software.

Ethical approval was obtained from the institutional review board prior to data collection. Written informed consent was secured from parents or guardians of all participants in accordance with established ethical standards in educational research.

## 3. RESULTS

Table 1. Creative Thinking Test Adapted from the Torrance Tests of Creative Thinking (TTCT)

| Aspect | Group | Mean | Std. Dev | Min | Max | Difference |
|---|---|---|---|---|---|---|
| Fluency | Experimental | 76.77 | 7.73 | 61 | 93 | +23.03 |
| | Control | 53.74 | 6.01 | 43 | 65 | |
| Flexibility | Experimental | 72.89 | 6.55 | 60 | 87 | +22.92 |
| | Control | 49.97 | 5.34 | 43 | 61 | |
| Originality | Experimental | 74.40 | 8.19 | 59 | 90 | +23.63 |
| | Control | 50.77 | 6.39 | 39 | 61 | |
| Elaboration | Experimental | 73.23 | 9.10 | 55 | 87 | +21.89 |
| | Control | 51.34 | 6.55 | 40 | 64 | |

Table 1 presents the descriptive statistics of students' creative thinking scores across four dimensions. Across all dimensions, the experimental group consistently achieved higher mean scores than the control group. The largest mean differences were observed in originality (23.63 points) and fluency (23.03 points), followed by flexibility (22.92 points) and elaboration (21.89 points), indicating a uniform pattern of higher creative thinking performance among students exposed to the intervention

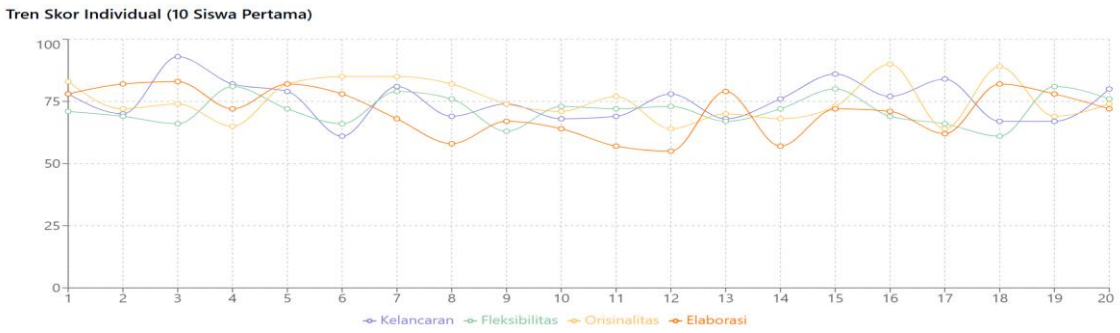


Figure 1. Individual Score Trends of Creative Thinking Test (TTCT)

Figure 1 illustrates individual score trends for the first ten students across multiple observation periods. The visual inspection indicates variability in individual performance trajectories across all four dimensions. Fluency and flexibility scores show relatively stable patterns across observation points, whereas originality and elaboration demonstrate greater fluctuation. Toward the final observation periods, scores across all dimensions tend to converge within a higher range, indicating increased consistency in individual performance by the end of the intervention period.

Table 2. Independent Samples Test

| Independent Samples Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| learning outcomes | Equal variances assumed | 1.091 | .300 | 6.954 | 68 | .000 | 13.200 | 1.898 | 9.412 | 16.988 |
| | Equal variances not assumed | | | 6.954 | 67.244 | .000 | 13.200 | 1.898 | 9.411 | 16.989 |

Levene's Test indicated no significant difference in variance between the experimental and control groups ($F = 1.091$, $p = .300$), confirming that the assumption of homogeneity of variance was met. The independent samples t-test revealed a statistically significant difference in learning outcomes between the two groups, $t(68) = 6.954$, $p < .001$, with a mean difference of 13.20 points

Table 3. t-Test Results and Effect Size

| Analisis | Statistical Value | p-value | Mean Difference | 95% CI (Lower–Upper) | Cohen's d | Interpretasi |
|---|---|---|---|---|---|---|
| Independent Samples t-test | t(68) = 6.95 | < .001 | 13.20 | 9.41 – 16.99 | 1.66 | Very big effect |

As shown in Table 3, the effect size analysis yielded a Cohen's d value of 1.66, indicating a very large effect. This result demonstrates that the observed difference between the experimental and control groups was not only statistically significant but also substantial in magnitude.

## 4. DISCUSSION

The findings of this study indicate that students exposed to the combined use of Digital Wiki Boards and the KWL strategy demonstrated significantly higher learning outcomes than those receiving conventional instruction, with a very large effect size (Cohen's d = 1.66). While this result confirms both statistical and practical significance, it should be interpreted as evidence of strong instructional effectiveness within the specific research context rather than as a claim of universal applicability. The substantial mean difference (13.20 points) suggests that the integration of collaborative digital tools and metacognitive scaffolding can meaningfully enhance elementary students' creative and analytical thinking when appropriately implemented.

The observed improvements may be attributed to the affordances of Digital Wiki Boards as collaborative learning spaces that support active knowledge construction. Consistent with socio-constructivist perspectives, such environments encourage shared cognitive responsibility, peer interaction, and iterative refinement of ideas. Prior studies have linked these collaborative processes to gains in creative fluency and cognitive flexibility, as learners are required to articulate, negotiate, and revise their thinking in response to peer input (Hu et al., 2022; Lee et al., 2021). In the present study, these affordances appear to have supported higher performance across all measured dimensions of creative thinking, including fluency, flexibility, originality, and elaboration.

The KWL strategy likely played a complementary role by providing structured metacognitive guidance within the collaborative digital environment. By organizing learning into phases of prior knowledge activation, goal setting, and reflective consolidation, KWL supports learners' ability to monitor and regulate their cognitive processes (Zouhor et al., 2016). This structured reflection aligns with theoretical perspectives emphasizing the interdependence of cognition and metacognition in the development of analytical thinking and problem-solving skills (Sercenia & Prudente, 2023). Within the present intervention, the KWL framework may have helped students engage more deliberately with learning tasks, thereby supporting reasoning, comparison, and inference during collaborative activities.

Taken together, the integration of Digital Wiki Boards and the KWL strategy appears to create a balanced instructional environment that combines openness and structure. Rather than relying solely on technological affordances or metacognitive scaffolds in isolation, the combined approach supports both divergent and convergent thinking processes. This finding is consistent with previous research suggesting that blended instructional designs can enhance creative idea generation while simultaneously strengthening analytical evaluation through structured inquiry and collaborative critique (Chen & Tsai, 2021; Soleimani et al., 2018).

The individual score trends observed across creative thinking dimensions further suggest that students' performance trajectories were not uniform, particularly during the early and middle phases of the intervention. Variability in originality and elaboration scores may reflect transitional periods in which students adjusted to new learning demands and collaborative norms. Over time, the convergence of scores toward higher ranges indicates increasing consistency in performance, suggesting that sustained exposure to the combined instructional approach may support the stabilization of higher-order thinking skills.

From a practical perspective, these findings support the use of Digital Wiki Boards and the KWL strategy as complementary components of technology-enhanced instruction in elementary education. The collaborative features of digital tools facilitate peer interaction and shared meaning-making, while metacognitive strategies provide essential guidance for regulating learning processes(Andrayani et al., 2025; Shadiev et al., 2025). However, the effectiveness of this integration is contingent upon thoughtful instructional design and alignment with learners' developmental characteristics.

In this regard, teacher preparedness emerges as a critical factor. Effective implementation requires not only technical proficiency in using digital tools but also pedagogical competence in applying metacognitive strategies to scaffold students' thinking (Miandoab et al., 2019). Prior research has emphasized that targeted professional development can enhance teachers' ability to support reflective and self-regulated learning in technology-rich environments (Ortega-Ruipérez et al., 2024). Moreover, institutional support in the form of flexible curricula, adequate resources, and collaborative planning among teachers is necessary to sustain innovative instructional practices (Garcia-Garcia et al., 2022; Maharani et al., 2023).

Despite the promising results, this study has several limitations that warrant consideration. The quasi-experimental design and the use of a single school context limit the generalizability of the findings. Additionally, the relatively short intervention period may not capture long-term effects on students' creative and analytical thinking development. Future research should therefore examine the longitudinal impact of integrating digital collaborative tools and metacognitive strategies across diverse educational contexts and explore how variations in instructional design influence learning outcomes

## LIMITATIONS AND FUTURE RESEARCH

Despite the robust findings of this study, several limitations should be acknowledged. First, the quasi-experimental design employed non-randomized group assignment, which may limit causal inference

despite the strong statistical and practical effects observed. Although baseline equivalence was addressed, uncontrolled contextual factors within intact classrooms may have influenced student outcomes.

Second, the study was conducted in a single elementary school within a specific regional and cultural context. As a result, the generalizability of the findings to other educational settings, grade levels, or sociocultural environments should be approached with caution. Differences in school infrastructure, teacher expertise, and students' prior exposure to digital learning tools may moderate the effectiveness of the intervention.

Third, the duration of the intervention was relatively short. While significant gains in creative and analytical thinking were observed, the study did not examine the long-term sustainability of these cognitive improvements. It remains unclear whether the observed effects would persist over extended instructional periods or transfer to other subject domains.

Future research should address these limitations by employing randomized controlled designs across multiple schools and regions to enhance external validity. Longitudinal studies are also recommended to investigate the durability of creative and analytical thinking gains over time. Additionally, future studies could explore mediating variables such as students' metacognitive awareness, collaboration quality, or teacher instructional practices to better understand the mechanisms underlying the observed effects. Comparative studies examining different configurations of digital tools and metacognitive strategies may further refine evidence-based instructional models for elementary education.

## 5. CONCLUSION

This study demonstrates that the integration of Digital Wiki Boards and the KWL strategy can significantly enhance elementary students' creative and analytical thinking skills. The findings reveal statistically significant differences between experimental and control groups, accompanied by a very large effect size, indicating that the combined digital–metacognitive approach yields substantial educational benefits within the studied context.

Digital Wiki Boards facilitate collaborative knowledge construction and active engagement, supporting key dimensions of creativity such as fluency, flexibility, originality, and elaboration. Simultaneously, the KWL strategy provides essential metacognitive scaffolding that guides students in organizing prior knowledge, setting learning goals, and reflecting on newly acquired understanding. The synergy between these components creates a balanced learning environment that supports both divergent and convergent thinking processes.

Beyond its empirical contributions, this study offers practical insights for the design of technology-enhanced instruction in elementary education. The results underscore the importance of aligning digital tools with structured pedagogical strategies to foster higher-order thinking from an early age. While further research is needed to examine long-term effects and broader applicability, the present findings suggest that thoughtfully integrated digital and metacognitive interventions can play a meaningful role in preparing students to meet the cognitive demands of 21st-century learning.

### Author Contributions:

Conceptualization, Darsan; Methodology, Darsan and Wulan; Software, Wulan; Validation, Darsan and Wulan; Formal Analysis, Darsan; Investigation, Wulan; Resources, Darsan; Data Curation, Wulan; Writing—Original Draft Preparation, Darsan; Writing—Review & Editing, Darsan and Wulan; Visualization, Wulan; Supervision, Darsan; Project Administration, Darsan; Funding Acquisition, Darsan.

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.Conflicts of Interest:

The authors declare that there are no conflicts of interest regarding the publication of this paper. The authors have no financial, personal, or institutional relationships that could be perceived as influencing the representation or interpretation of the reported findings.

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